A video output amplifier. Amended text 12 October 2000

The invention relates to a video output amplifier for conversion of an intensity signal, consisting of a static and a dynamic component, into a control voltage for an electron gun in a cathode ray tube, comprising a first voltage supply with a voltage commensurate with the operating characteristics of the cathode ray tube, an input terminal for the video signal and an output terminal for the control voltage, and a linear amplification stage for at least the static component of the video signal, consisting of a first transistor, a linear push-pull amplifier stage for the fast dynamic components of the video signal consisting of said first transistor and a second transistor, and a third transistor for elevating the static component of the video signal from a voltage level corresponding to the input to that of the first supply voltage, and a feedback resistor. It is a purpose of the invention to provide a video output amplifier of this type in which the power loss is reduced considerably in comparison to known constructions in order that particular cooling means, such as cooling fins, may be avoided.

Cathode ray tubes (CRTs) are in general use in television receivers as well as in monitors for computer installations or personal computers, and video output amplifiers are used for driving such CRTs. Video output amplifiers are known and in practice comprise an output stage, the output terminal of which delivers a control voltage which is intended to control an electron beam in a CRT by modulating a suitably high voltage on the cathode. The bandwidth of the output signal is up to 5 MHz in generally known circuits for television. Discussions regarding television in the present text may be directly transferred to monitors and other equipment with a cathode ray tube.

The control voltage may be divided into two components: a static or only slowly varying component which contains the momentarily static intensities and slower intensity variations, and a dynamic component which contains the fast intensity variations. The input signal to the video output amplifier is provided by a signal processing circuit with output voltages in the range from +1 V to +6 V, while the output signal from the video output amplifer correspondingly is in the range +150 V

to +50 V which means that a video output amplifier for use in connection with television must have a supply voltage in the range +200 V. The fastest intensity variations in the output signal are ca. 100 V and occur in the course of ca. 100 ns which that a video output amplifier must be capable of delivering fairly large capacitive currents to the stray capacitances which load the output terminal which in its turn requires the quiescent current in amplifiers with class A output stages to be comparatively high.

The power loss in a class-A output stage is high. The comparatively high quiescent current combined with the high supply voltage cause the total power loss in the output stage to be high, and it becomes necessary to utilise external cooling means, such as cooling fins. In case the bandwidth of the video signal increases to e.g. 10 MHz, which is necessary in flicker-free television, where the deflection frequency is doubled, the power loss is correspondingly increased in a class-A output stage, and it is hence still more desirable to reduce the quiescent current in the output stage. To this end one may use e.g. a class-B output stage where an improvement may be obtained. One measure of the improvement may be the degree of increase in the proportion between the bandwidth of the video signal and the power loss of the video output amplifier used, and in class-B there is in practice obtained a halving of the power loss for a given bandwidth. Another measure of the improvement may be expressed as the reduction of the area below a curve which represents power drained from the voltage supply during a prescribed time function for the driving.

Circuits for the control of a CRT have been described in a series of articles in the German monthly FUNKSCHAU under the general title "Schaltungen zur Ansteuerung der Farbbildröhre", Part 1 (No. 21, 1987, p. 60), Part 2 (No. 22, 1987, pp. 83-86), Part 3 (No. 23, 1987, pp. 53-56). The amplifiers described are linear class AB and class B amplfiers. However, the known class AB output stages still have to use a considerable quiescent current, which only reduces the power loss to 50% with respect to a corresponding class A stage. The known class B output stages need a clamp function (a high voltage pulse has to be provided) to maintain the bias voltage for the upper output transistor, and this complicates the circuit considerably.

In US-A-4,293,875 there is described a digital circuit using few components for the control of a CRT when supplied with graphic or dot-matrix signals. This circuit will not provide gray levels unless assisted by a complex modulator circuit and it cannot be feed-back controlled.
In certain and normally undesirable signal situations, such as noise from an empty television channel, the dynamically caused power losses in class-B may increase considerably, which together with the required increase in bandwidth cause even such solutions to require special cooling means. It is hence the purpose of the invention to provide an amplifier circuit which displays considerably reduced quiescent power losses in comparison to known constructions, in order that special cooling means may be avoided.

This is obtained in a particular manner according to the invention as described in the characterising part of claim 1. Thereby it is in particular obtained that the power loss is reduced because a part of the quiescent current is constituted by the current which must run anyway in the feedback resistor. The expression "essentially directly" is to be understood such that there may be one or more circuit elements provided between the emitter and the source for supply voltage, e.g. for linearisation or frequency compensation. Furthermore the invention may be realised by means of any amplifying element which is suitable for the particular frequency range, such as an FET, a MOSFET or similar, where "base" is in general to be understood as "control electrode".

An advantageous embodiment is particular in that the base of the output transistor is driven via the collector of a further transistor, the base of which is connected to reference voltage at a low voltage level, and the emitter of which is supplied with the static component of the control signal as a current from a driver amplifier. Hereby it is obtained that the control signal for the static component is lifted to the correct base bias voltage for the output transistor. The dynamic component is predominantly supplied via a coupling capacitor.

A further particular embodiment is characterised in that the operating point for the further transistor is adjusted so that further to the static component it additionally

supplies rectified dynamic components to the base of the output transistor for the control of its dynamic output current for charging any stray capacitances present. Thereby it is obtained that the rectified dynamic components which would otherwise have been supplied via C4 do not cause a reversal of the charge of C4 which would otherwise manifest itself as long streaks following image sequences with many fast contrast jumps.

A further particular embodiment is characterised in that a second output transistor is driven in such a way that the discharge current is drawn out of stray capacitances present during negative jumps in the dynamic signal component. The second output transistor is biased such that it does not draw any appreciable quiescent current.

In particular the large difference between peak power and quiescent power may necessitate the use of a power limiting circuit, because a video signal which contains many contrast jumps, such as white noise on the input terminal, would be able to overload a circuit which due to the large power savings according to the invention has been made less bulky and with weaker cooling means. Ordinary signals would not be influenced by such a power limiting circuit. Hence a further embodiment is particular by the characteristics given in claim 5.

The invention will be described in greater detail in the following with reference to the drawing, in which

Fig. 1 is a schematic block diagram for video circuits comprising an output amplifier with a high supply voltage according to prior art,

Fig. 2 shows an embodiment according to the invention,

Fig. 3 shows an embodiment with a changed driver stage and an output buffer stage,

Fig. 4 shows a test signal which has been used to determine the power consumption in different amplifier constructions,

Fig. 5 shows the modelling of the power consumption from the voltage supply to a known construction based on a class-A amplifier, and

Fig. 6 shows the modelling of the power consumption for a construction according to the invention.

In Fig. 1 is shown a block diagram for a part of a television receiver or video monitor. In block 1 those signals are processed which are to drive the individual electron guns in a CRT. There are three output terminals corresponding to the three colours of phosphor which are to be activated, and each output terminal is controlled as to instantaneous light intensity. We are dealing with a signal which gives extremely fast transients with respect to slowly varying base levels, as one particular dot of phosphor on the screen may be totally black while its neighbour on the same line may have full intensity.

Amplification of the signals for use at the CRT in block 3 occurs in three identical video output amplifiers 2 to the colours R, G, and B. In the present embodiment for the prior art the CRT is driven at the cathode, but with suitable bias voltages and a phase reversal of the output signal it can equally be a control grid which is driven. Here only the conditions pertaining to the colour G will be described. The G signal from the circuit 1 is taken to the base of the driver transistor DTr which obtains its current from a low voltage supply. From the emitter an in-phase signal is taken to the output transistor TR which obtains it current supply from a relatively high voltage via a collector resistor Rc, corresponding to the requirements of the CRT. The local components required by a practical circuit for adjusting the operating point of the driver transistor are not shown. The operating range of the video output amplifier is in practice adjusted by an adjustment by means of an adjustment in the signal processing circuit in block 1, in the form a manual "cut-off" adjustment during manufacture or by means of a control loop so that it corresponds to the CRT used. In this construction both the DC or slowly varying component and the high frequency content are transferred. When the amplifier in the active range of the CRT must be both linear and have a large bandwidth, the transistor TR is driven in class-A. This causes a quiescent current which is large according to the circumstances, and in combination with the

high voltage droop across the output stage this causes a high quiescent power consumption - in practice for this type of output amplifier in the order of 2 W in case of typical television image information.

In Fig. 2 is seen an embodiment of the invention in the form of a G video output amplifier comprising the supply voltage indicated as 200 V, an input terminal and an output terminal for driving the CRT. The input signal is fed via a summing resistor R2 to the positive terminal of a voltage follower IC1, which i.a. provides a low impedance driver stage for the output transistor TR3 via the coupling capacitor C4. Simultaneously IC1 is also the driver stage for the dynamic component to TR2. IC1 receives its power from a low voltage supply which is not shown. The emitter of transistor TR3 is connected directly to the voltage supply, and the output voltage is taken from the collector. The same signal is taken to negative feed-back via the resistor R3 to the point of summation on the positive input terminal of the voltage follower IC1. From an AC point of view the supply voltage is at signal ground, and the transistor TR3 may hence dynamically be seen as a "grounded emitter". The transistor TR1 converts the output voltage from the driver stage IC1 into a control current which is taken to the base of transistor TR3. As the voltage on the output terminal of the voltage follower IC1 is largely identical to the voltage at the summation point on its input terminal, which contains the negatively fed-back signal, the operating point of TR1 may be adjusted by means of R8 and R10, so that the control current contains both the static control current and the rectified part of the dynamic control current required by TR3, whereby non-intended reversals of charge of C4 are avoided.

The output transistor TR3 delivers the required DC current to maintain the DC potential on the output terminal. Furthermore TR3 delivers the charging current to the stray capacitances (in the order of 15 pF) during positive voltage steps, because it draws the discharge current out of the stray capacitances. This construction has been used rather than a passive connection to ground, because the quiescent current may then be kept at a low value in the order of 1 mA, while the charge reversal current to the stray capacitances may reach 15 mA. TR2 is provided with a signal from the driver stage IC1 via the coupling capacitor C3. D1, R17 and R18 establish a

temperature compensated bias on the basis of TR2. The bias and R18 are determined so that the quiescent current in TR2 is maintained in the order of 1 mA mentioned and such that the bias on the base of TR2 may be influenced in the negative direction by the increasing control current which appears during many fast intensity variations. Thereby the control current to TR2 is limited and hence the dynamically determined power losses in order that no need for special cooling means arises. C3 is adjusted so that the time constant for the power limiting becomes large enough so that short series of fast intensity variations within a frame do not cause limiting. In practice the skilled person will fit linearising resistors in suitable places as well as current limiting resistors. Furthermore, a practical circuit would comprise a cut-off control loop, the function of which does not interfere with the present invention.

IC1 may advantageously be connected so that it provides a given voltage amplification, which gives a possibility of elevating the upper cut-off frequency of the video output amplifier.

In Fig. 3 is seen a video output amplifier according to the invention which is essentially identical in its function to that described with respect to Fig. 2. The difference is that the voltage follower IC1 is replaced by the emitter follower TR6 with the emitter resistance R4, and that there is added a buffer stage in the output consisting of the two transistors TR5 and TR4 with the zener diode D2. Furthermore there is shown a connection BCFB for beam current feedback.

In case the requirement for amplification and bandwidth is moderate it is sufficient to use an emitter follower TR6 as a driver. With an increase in the requirements it may be advantageous to use a discrete transistor amplifier with a certain voltage amplification as a driver in stead of the emitter follower TR6, and it may be further advantageous to comprise a limiter function in the transistor amplifer in such a way that the control current for TR3 is limited in the same way that the control current to TR2 is limited, cf. the description concerning Fig. 2.

It may be advantageous to include a buffer stage in the output of the amplifier, in particular if there is already a cut-off transistor, in that the dynamic power losses may

be distributed among four transistors rather than among only two. In the circuit of Fig. 3 TR4 functions as a cut-off transistor most of the time, where the slowly varying beam currents from the CRT are taken through TR4 to the video signal processing circuit via the terminal marked BCFB. During fast intensity variations TR4 functions as a buffer, because a part of the stray capacitances are discharged via TR4 and D2 to ground. The zener voltage on D2 is chosen such that the beam current is fed to the video signal processing circuit and not to ground. It is obvious that other voltage limiter circuits may perform the same function. TR5 is without current most of the time but it acts as a buffer during fast positive intensity variations where it charges a part of the stray capacitances.

In Fig. 4a is seen a test signal which is used in modelling a 5 MHz amplifier. The signal consists of two pulses with risetimes of ca. 100 ns, in that the pulses start from black and reach 50% and 100% maximum signal. The total duration of the test signal is ca. 3.5 μs, and it may be provided repetitively from a signal generator. The voltage amplitude on the input is 1 V and 2 V, respectively. The corresponding output signal is shown in Fig. 4b and goes from an output voltage of 160 V and falls during the two pulses to 110 V and 55 V, respectively. The signal is hence in reverse phase with respect to the input signal and is intended for cathode control of the CRT.

In Fig. 5 is shown the power consumption from the voltage supply of a 5 MHz output stage in class-A during the pulses, and it will be noted that the quiescent power is 1 W (black), and that the power consumption rises to 2 W (50% intensity) and 3.5 W (max. intensity) during the pulse cycle. As a measure of the power consumption it may be judged that the area below the curve is 6.5 μWs, i.e. the energy consumed during a pulse cycle. The power taken from the low voltage power supply is not taken into consideration.

In Fig. 6 is similarly shown the power consumption from the voltage supply of a 5 MHz output stage according to the invention. It is seen that the quiescent power consumption is ca. 0.25 W and that the power consumption is very low during the whole cycle, except where the output voltage (Fig. 4b) is intended to rise with a steep flank towards the quiescent value. Hereby power surges of 1.7 W and 3.2 W,

respectively, are obtained. These peaks are hence up to 12 times the quiescent power consumption. The area below the curve may be judged to be 0.3 μWs, i.e. an improvement of more than 20 times with respect to prior art expressed as a class-A stage. In a practical amplifier 8-10 times may be obtained. The power taken from the low voltage power supply is not taken into consideration in this case either.

Video output amplifiers according to the invention will be suitable for integration due to the small power consumption.